Microline®

MODEL 296C
MICROWAVE RECEIVER
(Serial No. 10 and up)

OPERATING INSTRUCTIONS
AND
TECHNICAL DATA

SPERRY MICROWAVE ELECTRONICS COMPANY
DIVISION OF SPERRY RAND CORPORATION
CLEARWATER, FLORIDA

PUBLICATION NO. SJ-31-0003 MARCH 1959

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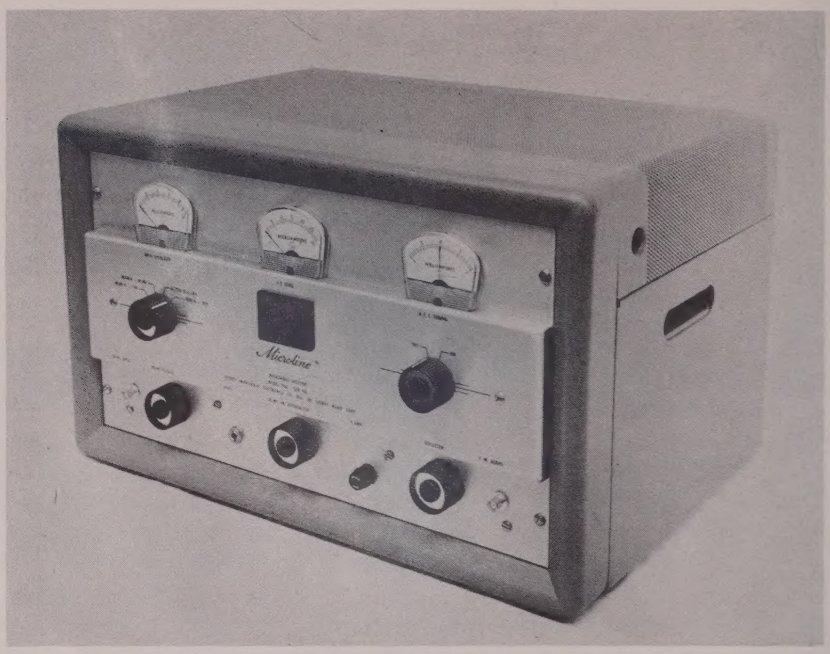
WARNING

HIGH VOLTAGE IS EMPLOYED IN THIS EQUIPMENT. OPERATING PERSONNEL MUST OBSERVE ALL SAFETY PRECAUTIONS TO PREVENT LOSS OF LIFE.

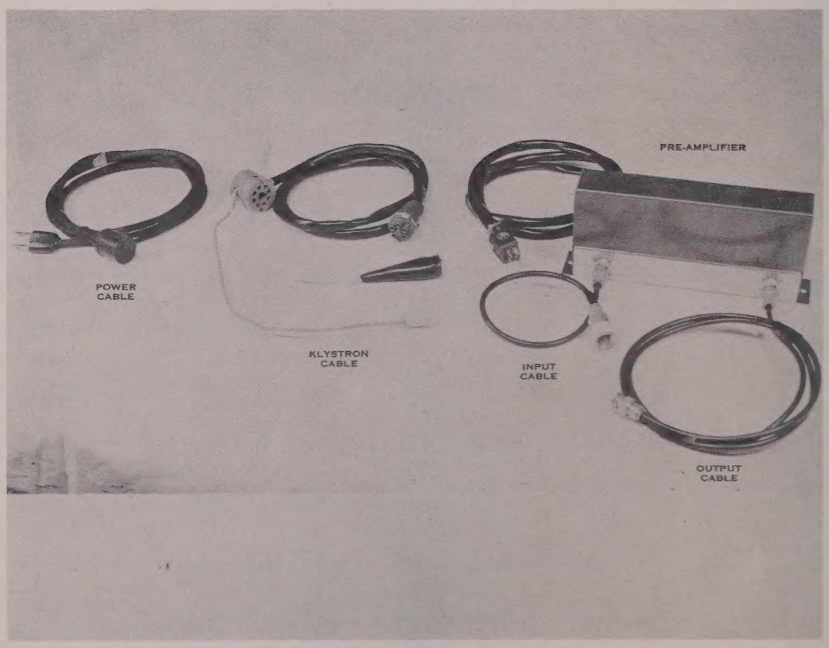
NEVER CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WHILE THE INSTRUMENT IS TURNED ON.

ALWAYS DISCONNECT OR SHUT DOWN THE 115-VOLT POWER SOURCE BEFORE ATTEMPTING TO ADJUST OR SERVICE THE EQUIPMENT INTERNALLY.

EXTREMELY DANGEROUS POTENTIALS DUE TO CHARGES RETAINED BY CAPACITORS, ETC. MAY EXIST IN THE EQUIPMENT AFTER POWER SHUTDOWN. TO AVOID CASUALTIES ALWAYS DISCHARGE AND GROUND ALL CIRCUITS BEFORE TOUCHING THEM.



MODEL 296C MICROWAVE RECEIVER



MODEL 296C MICROWAVE RECEIVER ACCESSORIES

FIGURE 1-1

SECTION I

GENERAL DESCRIPTION

1. PURPOSE OF EQUIPMENT

a. The Model 296 Microwave Receiver (figure 1-1) is a precision-calibrated, direct-reading instrument for measuring relative power within a range of 70 db at high radio frequencies. It is designed for operation over wide frequency bands determined by the characteristics of certain accessory equipment employed.

b. The relative power levels of the signals to be measured can be read directly in db from the dial of a highly accurate variable attenuator of the waveguide-below-cutoff type operating at a frequency of approximately 30 mc. The attenuator has an accuracy of 0.2 db.

c. The overall measurement accuracy depends upon the characteristics of a required accessory crystal mixer. The recommended crystal mixers are linear between 100 microwatts and the minimum detectable signal if the local-oscillator microwave power fed into the crystal is greater than one milliwatt.

d. When operated with recommended accessory equipment, the instrument is used with both c-w and certain modulated signals for:

(1) measuring wide ranges of r-f power accurately;

(2) calibrating r-f attenuators;

(3) measuring the insertion loss of microwave attenuators and directional couplers;

(4) measuring high standing-wave ratios in conjunction with precision standing-wave detectors;

(5) measuring antenna patterns.

2. GENERAL PRINCIPLES OF OPERATION

a. The heart of the Model 296 Receiver is a 30-mc precision calibrated attenuator. The microwave input to the receiver is mixed with the signal from an external local oscillator to produce a 30-mc signal. This signal passes through the calibrated attenuator, through an i-f amplifier and it then is detected. Power-level changes of the 30-mc signal are manually compensated by the calibrated attenuator which then provides an accurate indication of the power-level change of the original input signal.

b. The receiver includes an afc system of the constant i-f type with a time constant of about 1/5 second. In order to establish afc, manual tuning of the local-oscillator klystron is required. The afc system of the Model 296 is primarily intended for operation with c-w signals. Modulated signals can be used, but the afc will not function properly unless the modulation frequency is high enough so that the afc will not follow the modulation and thereby produce a frequency modulation of the klystron.

3. DESCRIPTION OF EQUIPMENT

a. The Model 296 consists of a 30-mc i-f attenuator, an i-f amplifier and level indicator, an afc circuit, klystron and receiver power supplies, a separate preamplifier, and necessary cabling. The instrument is mounted in a protective metal cabinet which also serves as a permanent dust cover. If necessary, the cabinet can be removed and the unit mounted to a standard relay rack.

b. Necessary cables and cords are supplied for connections to a power source, to an auxiliary klystron local oscillator, and to the preamplifier. A cable is also supplied for connecting the preamplifier to an external mixer. The preamplifier is supplied as a separate component so that it may be mounted as close to the mixer as desired.

c. The internal power supply is normally connected for use with the Sperry klystrons listed in Table 1-1 and a d-c power cable is supplied for that purpose. The range of beam voltage of the internal supply is 600 to 800 volts. In order to operate klystrons which require other beam voltages, the 296 contains a provision for connecting external beam and heater supplies by removing a shorting plug (see figure 1-2) at the rear of the chassis and using the exposed terminals for external power supply connections. In this case the reflector voltage (which provides automatic frequency control) is obtained from the internal supply. This supply is insulated for 3000 volts.

d. The frequency bands within which measurements can be made depend upon the characteristics of the mixer used. Fifteen Sperry Microline® Mixers are listed in Table 1-2, which gives the individual frequency range and corresponding transmission-line connector of each model. This list of mixers provides continuous coverage for measurements from 2.6 to 39.0 kmc (kilomegacycles). No mixers are supplied with the Model 296 Receiver.

e. Table 1-1 gives the seven types of Sperry reflex klystrons normally operated as local-oscillator signal sources by the Model 296 . These klystrons give coverage from 0.75 to 1.15 kmc and from 2.6 to 10.3 kmc. No klystron tubes are supplied with this instrument.

4. EQUIPMENT CHARACTERISTICS

a. Electrical

(1) Receiver Gain - 85 db min

(2) Receiver Bandwidth - 1.0 mc min

(3) Attenuation Range - continuously variable from 0 to 80 db on dial at 30 mc (not including insertion loss)

(4) Attenuator Dial Accuracy - ±0.4 db between zero and any higher point; ±0.2 db between five any any higher point

(5) Frequency Range - 29 - 32 mc

(6) Input Impedance (Attenuator) - 50 ohms

(7) 30-Mc I-F Amplifier Gain - 65 db min

(8) Bandwidth at 3-Db Points (Including Attenuator) - 1.3 mc min

(9) Discriminator Bandwidth - 1.3 mc min

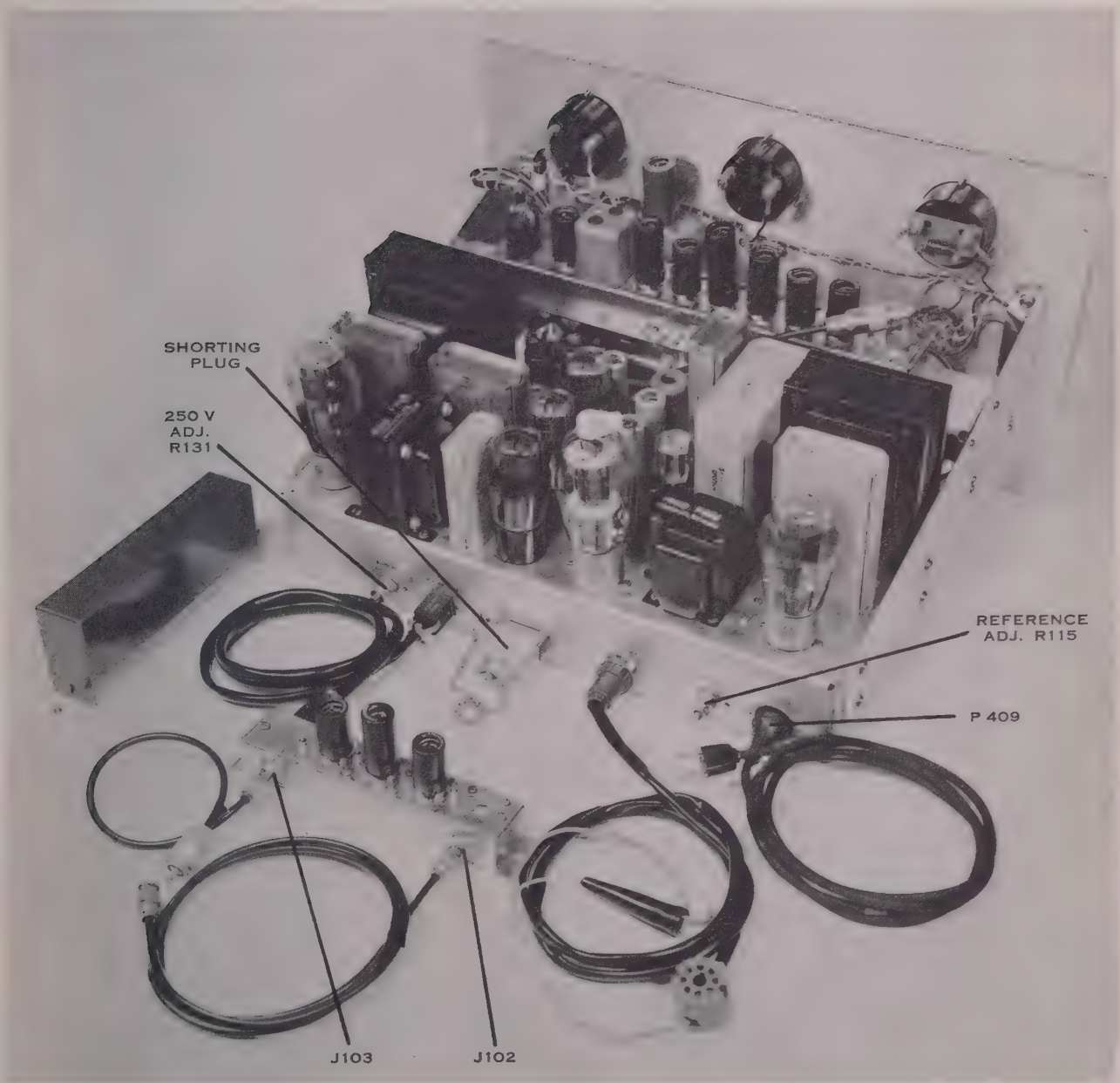


Figure I-2. Model 296 Microwave Receiver - Rear Chassis Connections

(10) Preamplifier Input - BNC connector - unbalanced line

(11) Preamplifier Gain - 30 db

(12) Preamplifier Bandwidth - 2.0 mc min

(13) Local-Oscillator Operating Frequency - 30 mc above signal frequency

(14) Local-Oscillator Power Supply - 600 to 800 volts, 50 ma continuously variable, positive grounded

(15) Reflector Supply - 0 to -500 volts, continuously variable

(16) Input Power (Including Preamplifier) - 115 volts, 60 cycles, 250 watts

(17) Temperature and Humidity Effects - negligible

b. Physical

(1) Fittings (30 MC INPUT and F-M AUDIO) - BNC panel receptacles

(2) Overall Cabinet Size - 21 9/16 inch wide, 14 7/8 inch deep, 13 inch high (Panel suitable for rack mounting)

(3) Weight - 75 pounds

(4) Cabinet Finish - Armorhide blue

5. ACCESSORIES FURNISHED

a. 30-Mc Preamplifier - 30-db gain

b. Klystron D-C Power Cable - Three-feet long, fitted with octal connector at each end.

c. Preamplifier Cables - Two flexible coaxial cables with male fittings at each end: (1) BNC - UHF, (1) BNC - BNC

d. Power Cable - Five-feet long, 115 volt fittings

e. Vacuum Tubes - 5 - 6AK5, 4 - 0B2, 4 - 6Y6, 2 - 6SH7, 2 - 5R4GY, 2 - 6J5, 1 - 6SN7, 1 - 6J6, 1 - 807, 1 - 6X4

6. ACCESSORIES REQUIRED

a. Crystal Mixers - Applicable Microline Mixers as listed in Table 1-2

b. Microwave Sources - Applicable klystrons for local oscillator as listed in Table 1-1

c. Klystron Cooling Blower - For best klystron stability use blower with nominal air-stream of approximately 10 cubic ft./min.

TABLE I-1

KLYSTRONS WHICH MAY BE POWERED
BY THE MODEL 296

Type	Frequency Range
2K21	0.75 - 0.96
2K23	0.95 - 1.15
2K41	2.6 - 3.3
2K42	3.3 - 4.2
2K43	4.2 - 5.7
2K44	5.7 - 7.5
2K39	7.5 - 10.3

TABLE I-2

MICROLINE MIXERS FOR USE WITH THE MODEL 296 *

Mixer Model No.	Signal Input Connector	AN Type	Frequency Range Kmc
337C	Type N	UG-23B/U	2.6 - 4.0
338	Type N	UG-23B/U	4.0 - 6.0
339	Type N	UG-23B/U	6.0 - 8.2
379	1-x 1/2-inch Waveguide	UG-39/U	8.2 - 12.4

*For further information on mixers contact the Sperry Gyroscope Company, Special Electronic Sales Department, Great Neck, Long Island, New York.

SECTION II

OPERATION

1. INSTALLATION OF LOCAL-OSCILLATOR KLYSTRON

a. Use of the Internal Klystron Beam Supply

(1) Connect the klystron power cable to receptacle J-103 (see figure 1-2). The plug, which is attached by a chain to the rear of the chassis, must be inserted in receptacle J-102. The tube socket on the local-oscillator klystron power cable supplied is wired for use with the Sperry klystron types listed in table 1-1. The B+ lead is terminated with an alligator clip which provides a good ground connection when firmly fastened to some convenient point on the klystron shell. The reflector lead terminates in an insulated ceramic cap.

(2) For other klystron types operating in the beam-voltage range from 600 to 800 volts, refer to the applicable cable and power-supply schematics to determine the proper connections. If it becomes necessary to alter the tube-socket wiring or to use adapters, circuit tie-points should not be made on unused pins because internal tube connections may be shorted, resulting in damage to the power supply or tube. If filament wiring is changed, one side of the heater should be connected directly to the cathode contact on the tube socket, not through a heater lead in the cable.

WARNING

NEVER CHANGE KLYSTRONS OR TOUCH CONNECTIONS WHEN THE 296 RECEIVER IS TURNED ON.

b. Use of an External Beam Supply - Provision is made in this instrument for using an external supply for heater, beam and control-grid voltages by connection to J-102. To use an external supply, remove the shorting plug from J-102 and insert a cable from the external supply using terminals B, C, F, and H on J-102. Refer to the schematic in figure 5-5 for connections to J-102. The supplied cable can be used with klystrons whose maximum reflector voltage does not exceed -2500 volts with respect to ground.*

NOTE

The klystron cable supplied has the grid and cathode connected together and cannot be used without modification for tubes which require control-grid operation above or below cathode potential.

2. EQUIPMENT INTERCONNECTIONS

A block diagram of the complete equipment is given in figure 5-1. The accessory components required but not supplied are shown outside of the broken lines in the figure. The equipment is assembled for operation as follows:

- - - - - - -

* Since the positive side of the reflector supply is connected to the negative side of the beam supply, the 2500 volts represents the sum of the beam and reflector voltages referred to ground potential.

a. Connect the klystron to the receiver as described in the preceding paragraph.

b. Connect the output of the klystron to the local-oscillator input of the mixer using sufficient padding or matching as required, and couple the output of the mixer to the pre-amplifier.

c. Using the cable supplied, connect the output of the preamplifier to the 30 MC. INPUT jack on the receiver panel.

d. Connect the preamplifier power cable between the preamplifier chassis and the PREAMPLIFIER d-c output receptacle, J-101, on the rear panel of the receiver.

e. For some applications the preamplifier may be omitted. In such cases the mixer output is connected directly to the 30 MC. INPUT jack of the receiver.

3. FUNCTIONS OF CONTROLS

a. The operating controls, fittings and indicator meters (see figure 1-1) are located on the front panel.

b. A switch (S402) located on the front panel permits the direction of the crystal current flow through the meter to be reversed should this be required.

Figure 1-2 is a rear view of the 296 showing the PREAMPLIFIER and KLYSTRON d-c input voltage connectors, the voltage regulator adjustments for the amplifier plate voltages and the klystron beam voltages, the detachable power cord, the recessed 115V input plug (P-409), and the EXTERNAL BEAM receptacle (J-102) for introducing d-c voltages from an external power supply.

c. The designations and functions of all panel controls and receptacles are listed in the following table.

TABLE 2-I. PANEL CONTROL AND RECEPTACLE FUNCTIONS

Panel Designation	Description	Functions
ON-OFF	Toggle Switch	Controls a-c input to entire chassis including local-oscillator klystron power supply. Red pilot lamp on front panel indicates application of input voltage
BEAM VOLTS	Fluted Control Knob	Clockwise rotation of knob increases beam voltage over the range from -600 to -800 volts with respect to ground (shell of local-oscillator klystron). Red pilot lamp glows when beam voltage is present at KLYSTRON receptacle, J-103, on rear of chassis.
REFLECTOR	Fluted Control Knob	Adjusts voltage supplied to local-oscillator reflector electrode over range from -10 to -500 volts with respect to applied beam voltage. Clockwise rotation increases voltage applied.
CRYSTAL 0-1 MA. BEAM 0-1 KV. BEAM 0-50 MA.	Selector Switch	Couples LOCAL OSCILLATOR panel meter to L-O klystron circuit for monitoring either beam voltage (BEAM 0-1 KV. position) or beam current (BEAM 0-50 MA. position). Also provides reading of mixer crystal current (CRYSTAL 0-1 MA. position) by coupling the meter to mixer circuit.

Panel Designation	Description	Functions
LOCAL OSCILLATOR	Milliammeter	Indicates L-O klystron beam voltage and current. Also used to measure crystal current resulting from the klystron r-f output introduced into the mixer from the local oscillator or signal source.
30 MC. DB. ATTENUATION	Control Knob, Calibrated Dial and Vernier	Knob provides adjustment of precision calibrated 30-mc attenuator which controls the i-f signal level introduced into the i-f amplifier from the preamplifier. Direct-reading dial and vernier indicates relative i-f power levels within 0.1 db.
I.F. LEVEL	Microammeter 0-30 ua full scale	Measures rectified signal level at output of i-f amplifier.
A.F.C. TUNING	Voltmeter	Indicates magnitude of discriminator error-signal voltage so necessary adjustments can be made to obtain proper operation of the afc circuit. (Absence of off-zero voltage shows that error voltage is zero or that no i-f signal is present.)
30 MC. INPUT	BNC Panel Receptacle	Couples i-f output from mixer and/or pre-amplifier to the 30-mc precision attenuator in the instrument.
I.F. LEVEL	Panel Jack	Enables use of an external d-c indicator or recorder to measure the i-f level.
F.M.-AUDIO	BNC Panel Receptacle	Enables monitoring of discriminator error voltage with an external indicator.

WARNING

HIGH VOLTAGES EXIST IN THIS EQUIPMENT. IN THE PERFORMANCE OF ANY MAINTENANCE ADJUSTMENT OR TEST, OPERATING PERSONNEL MUST OBSERVE ALL SAFETY PRECAUTIONS TO PREVENT LOSS OF LIFE.

DANGEROUS POTENTIALS MAY EXIST AFTER POWER SHUTDOWN IN THE EQUIPMENT DUE TO CHARGES RETAINED BY CAPACITORS, POSSIBLE BREAKDOWN OF COMPONENTS, ETC. TO AVOID CASUALTIES, ALWAYS DISCHARGE AND GROUND ALL CIRCUITS BEFORE TOUCHING THEM.

4. PRELIMINARY TUNING AND ADJUSTMENT SEQUENCE

When the necessary details involved in setting up the equipment have been completed as described in the previous paragraphs, the instrument is ready to be turned on and the local-

oscillator klystron tuned up to the required operating frequency. For best operation, the order of adjustments listed below should be carefully observed:

a. Detailed Adjustment Procedure

(1) Turn the toggle switch to the ON position.

(2) Turn the selector switch to BEAM 0-1 KV. The meter should read between 600 and 800 volts.

(3) Switch to BEAM 0-50 MA. The beam current should read between 25 and 50 ma.

(4) Turn the REFLECTOR knob until an increase is noted in the beam current, indicating r-f oscillation of the local-oscillator klystron. Several such positions of the knob may be found.

(5) Switch to CRYSTAL 0-1 MA. and turn the REFLECTOR knob for maximum crystal current. Decouple the local oscillator from the mixer as necessary to keep the meter pointer on scale.

(6) Tune the local-oscillator cavity with the aid of a frequency meter to 30 mc above the signal frequency. When the local oscillator is thus tuned, detune or disconnect the wavemeter.

(7) Again maximize the crystal current with the REFLECTOR knob.

(8) With an r-f signal present set the ATTENUATION control for minimum attenuation and tune the local-oscillator cavity slowly until a response is noted on the I.F. LEVEL meter and the A.F.C. TUNING meter pointer is centered.

(9) Set in maximum attenuation and again maximize crystal current with the REFLECTOR knob.

(10) Set in minimum attenuation and retune the local-oscillator cavity until the I.F. LEVEL meter reads maximum and the A.F.C. TUNING meter pointer is centered. If this step results in an appreciable decrease in crystal current, the step should be repeated. The criterion of exact tuning is that the crystal current and the A.F.C. TUNING meter readings do not change as the attenuation is varied from maximum to minimum. The I.F. LEVEL reading will vary during this test.

(11) For best conversion efficiency and noise condition the crystal current should be set at about 0.6 ma.

(12) When tuning the local-oscillator cavity and searching for an i-f indication, a response may be obtained when the local-oscillator is operating at the image frequency. This condition will be obvious from the action of the A.F.C. TUNING meter. The meter pointer will not center, but will remain considerably off center to one side or the other, depending upon the direction from which the image frequency is approached.

b. Summary of Tuning Steps

(1) Set local oscillator to 30 mc above signal frequency.

(2) With ATTENUATION knob set to maximum position, maximize crystal current with REFLECTOR control.

(3) With ATTENUATION knob adjusted for minimum setting, tune local-oscillator klystron for an indication on I.F. LEVEL meter.

(4) Repeat step (2).

(5) With minimum attenuation, retune local-oscillator klystron until AFC indicator is centered and I.F. LEVEL meter indicates presence of i-f signal.

(6) Repeat steps (4) and (5) as necessary until crystal current and AFC meter do not change readings as ATTENUATION control is varied.

5. OPERATING PROCEDURE

a. General

(1) The Model 296 Microwave Receiver requires an initial warm-up period for stabilizing the microwave output of the klystron. In order to achieve maximum frequency stability, the klystron should be protected from casual or intermittent air drafts. A smooth, steady air stream should be used for forced-air cooling.

(2) At the start of the warm-up period, the afc tuning meter pointer may go off scale. It will gradually approach zero center as the amplifier reaches thermal equilibrium.

(3) For optimum conversion, the crystal current should be set at 0.6 ma with only the local-oscillator source feeding into the crystal mixer. The addition of the signal to be measured should cause no noticeable change in the crystal current.

(4) Excessive signal amplitude can impair the linearity of conversion in the mixer. Linearity is assured when there is less than 75 ua of rectified crystal current with the local-oscillator input removed. Under these recommended conditions of crystal current, there is no danger of deviation from linearity due to crystal conversion characteristics or amplifier saturation.

(5) Care should be taken to see that no connecting cables, particularly r-f cables to the mixer, introduce any discontinuity or erratic operation under slight flexing.

b. Measurement of Relative Power - Relative power measurements of greatest accuracy are obtained by operating with the i-f level meter set at a constant level, using the 30-mc attenuator to read the difference in power levels as the attenuation in the component under test is varied. In certain applications, however, it may be desired to read differences directly on the meter, or on an external d-c indicator or recorder. The d-c output voltage of the receiver is linear with respect to the microwave voltage (or proportional to the square root of the microwave power) over a range of d-c output voltages from 0.3 to 3.0 volts, or from 3 to 30 microamperes on the i-f level meter. If an external indicator is used it should have an input impedance of at least 9.1 megohm.

c. Measurement of Attenuation

(1) A typical use of the Model 296 Receiver is illustrated by the measurement of the attenuation of a fixed or variable attenuator. In this application the equipment consists of a microwave oscillator, tuner, pad attenuator, monitor directional coupler and detector, a crystal mixer and the Model 296 . It may also be necessary to use an impedance-matching transformer with the oscillator and a pad attenuator for matching the mixer. After setting up the microwave components, the receiver is tuned and adjusted as described in paragraph 4.

(2) The receiver attenuator should be adjusted to a dial setting which is at least five db above the maximum attenuation to be measured. The signal amplitude is then adjusted to set a reference level on the I.F. LEVEL panel meter. Next the attenuator under test is inserted

in the transmission line and the receiver attenuator adjusted to obtain the same reference level on the I.F. LEVEL meter. The difference between the receiver attenuator dial readings is equal to the attenuation of the unit tested.

d. Measurement of Coupling

(1) The same procedure as used in the preceding paragraph may be applied to the measurement of attenuation of directional couplers. In this application the receiver reference level is first adjusted with the mixer on the load end of the primary line of the coupler. The mixer is then moved to the output connector of the secondary line of the coupler, and the primary line is terminated in a load with a low VSWR. The measured difference between the receiver attenuator dial readings is equal to the attenuation of the directional coupler.

(2) In performing attenuation measurements of any type it is essential that the power into the directional coupler or attenuator under test be maintained at a constant value. In order to avoid measurement errors due to variations in power, the power is monitored by means of a directional coupler inserted in the line with a detector attached to the secondary line of the coupler.

SECTION III

THEORY OF OPERATION

1. BLOCK DIAGRAM DESCRIPTION

a. A microwave receiver is essentially the second detector for a heterodyne system. A first detector (mixer) and a local oscillator are required in addition to the receiver to complete the system.

b. A block diagram of the heterodyne system as used with the Model 296 is given in figure 5-1. With a local-oscillator power of greater than 1 milliwatt and a frequency of 30 mc greater than the signal frequency (f_1), the 30-mc i-f output power from the mixer will be proportional to the signal power for signal input powers of less than 100 microwatts. Consequently, relative levels of microwave signal power may be measured by making level measurements at 30 mc. As referred to here, the relative power level is defined as the measured db difference in signal-line output power caused, for example, by the insertion of an attenuator in the signal transmission line.

c. The 30-mc output from the mixer is amplified, transmitted through the attenuator, further amplified, detected (rectified) and indicated on a panel meter. The attenuator is set for a convenient reading on the I.F. LEVEL meter. If the signal level changes, the attenuator must be reset to obtain the same indicator meter reading. The difference in attenuation between the two settings is exactly the difference between the two signal levels. The detected output can be measured by an external indicator.

2. AUTOMATIC FREQUENCY CONTROL CIRCUIT DESCRIPTION

a. The afc circuit maintains the i-f signal at the peak of the amplifier response curve. For satisfactory measurement accuracy the i-f level must be made independent of signal frequency variations. In the Model 296 this is accomplished by means of the automatic frequency control formed by a servo system whose loop characteristics depend very largely on the variation of the local-oscillator frequency with reflector voltage changes.

b. The discriminator and afc amplifier are designed to have phase, gain and bandwidth characteristics satisfactory for use with klystrons as listed in Table 1-1. These klystrons may be operated as local oscillators at the fundamental frequency, f_1+30 mc, or with proper multiplier-mixers at certain sub-harmonic frequencies, (f_1+30 mc)/n, where n may be either 2 or 3. Higher values of n may be used, but control becomes more critical under these conditions.

c. Proper local-oscillator loading may be accomplished by inserting attenuation in the local-oscillator line. This attenuation, if made adjustable, may also serve to adjust the local-oscillator excitation level in the mixer crystal.

d. The reflector frequency-deviation rate in a klystron is different for each mode, being approximately inversely proportional to the reflector voltage. On the other hand the afc amplifier gain is directly proportional to reflector voltage with the result that afc gain is almost constant around that part of the loop comprising the discriminator (volts/mc),

d-c amplifier and reflector supply (mc/volt). The rest of the servo system which includes the mixer and i-f amplifier serves only to complete the loop and minimize the noise. The reflector frequency-deviation rate (mc/volt) of klystrons increases, in a general way, as the frequency increases. This characteristic is an asset since additional afc-loop gain is necessary at higher microwave frequencies in order to maintain the intermediate frequency within the fixed bandwidth.

e. The afc tuning voltmeter is connected between a fixed, regulated, reference voltage and a point in the d-c amplifier where the potential varies with the error signal. When the error voltage is zero, there is no potential across the tuning meter. This condition is obtained by adjustment of potentiometer R-405 which sets the amplifier voltage equal to the reference voltage. The no-error condition is obtained by setting in maximum attenuation of the i-f level (no signal). During operation an i-f error is indicated by an off-zero voltage reading of the tuning meter.

f. When tuning the local-oscillator reflector voltage, counteracting afc effects must be eliminated by setting in maximum attenuation to disable the afc. The reflector voltage should be adjusted to the center of the mode, i.e., to the point for which the crystal current is maximum. Frequency searching and tuning adjustments should be made by adjustments to the klystron cavity with minimum attenuation set in.

3. 30-MC VARIABLE ATTENUATOR DESCRIPTION

a. The precision, variable attenuator is of the waveguide-below-cutoff type consisting of two coils mounted in a section of cylindrical waveguide. The axes of the coils are parallel and intersect the axis of the waveguide at right angles. The coupling (attenuation) between coils is changed by moving one coil along the waveguide while the other remains fixed. Since there is no true r-f wave propagation in this waveguide from one coil to the other when operated below cutoff, the fields are exponentially attenuated within the guide. At frequencies far below cutoff the rate of attenuation is practically independent of frequency.

b. The coupling variation is not precisely exponential at very close spacing of the coils. Consequently, a minimum spacing is set so that the attenuator operates only within the exponential range beyond the initial minimum spacing.

c. Because of the tuned input and output circuits, the insertion loss (minimum attenuation) will change with variations in the intermediate frequency. This variation of insertion loss may be considered as part of the overall i-f response characteristic of the Receiver. The dial is scaled in equal divisions from 0 to 80 db. Zero on the scale includes the fixed insertion loss (initial minimum spacing) of 20 db, so that in effect zero scale setting represents 20 db; similarly, 80 db on the scale represents a total attenuation of 100 db.

SECTION IV

MAINTENANCE

WARNING

HIGH VOLTAGES EXIST IN THE EQUIPMENT. IN THE PERFORMANCE OF ANY MAINTENANCE ADJUSTMENT OR TEST, OPERATING PERSONNEL MUST OBSERVE ALL SAFETY PRECAUTIONS TO PREVENT LOSS OF LIFE.

DANGEROUS POTENTIALS MAY EXIST AFTER POWER SHUTDOWN IN THE EQUUPMENT DUE TO CHARGES RETAINED BY CAPACITORS, POSSIBLE BREAKDOWN OF COMPONENTS, ETC. TO AVOID CASUALTIES, ALWAYS DISCHARGE AND GROUND ALL CIRCUITS BEFORE TOUCHING THEM.

1. REMOVAL OF UNIT FROM CABINET OR RACK

The Model 296 Microwave Receiver may be removed from its cabinet or a standard rack by disengaging the four mounting screws on the front panel. Figure 4-1 shows a view of the top of the unit, while the bottom of the chassis is seen in figure 4-2.

2. VOLTAGE ADJUSTMENTS

a. Figure 1-2 shows the location of the local-oscillator beam-voltage regulator adjustment potentiometer, REFERENCE ADJ (R-115), and the B+ adjustment, 250 V.ADJ (R-131), both located on the rear of the chassis.

b. In adjusting these potentiometers, the following sequence should be used:

(1) The supplies must be properly loaded during the adjustments. On KLYSTRON connector J-103 use a 16,000-ohm, 50-watt resistor between cathode (pin E) and ground (pin F) to simulate klystron beam current. On PRE-AMPLIFIER panel receptacle J-101 connect a 4,000-ohm, 10-watt resistor between 150 volts (terminal 1) and ground (terminal 2) to simulate the pre-amplifier.

(2) Turn the Model 296 Receiver on in accordance with the instructions in paragraph 4, Section II.

(3) With the BEAM VOLTS knob turned fully clockwise turn the REFERENCE ADJ potentiometer (R-115) clockwise until the voltage between pins E and F on KLYSTRON panel connector J-103 is adjusted for -800 volts. This will set the beam voltage so that the proper operating range can be covered by the BEAM VOLTS panel control.

(4) Turn the 250 V. ADJ potentiometer clockwise until the voltage between terminals 1 and 2 on PREAMPLIFIER panel receptacle J-101 is set to +133 volts.

(5) While making these adjustments, check the voltages with a meter having an internal resistance of at least 1000 ohms per volt.

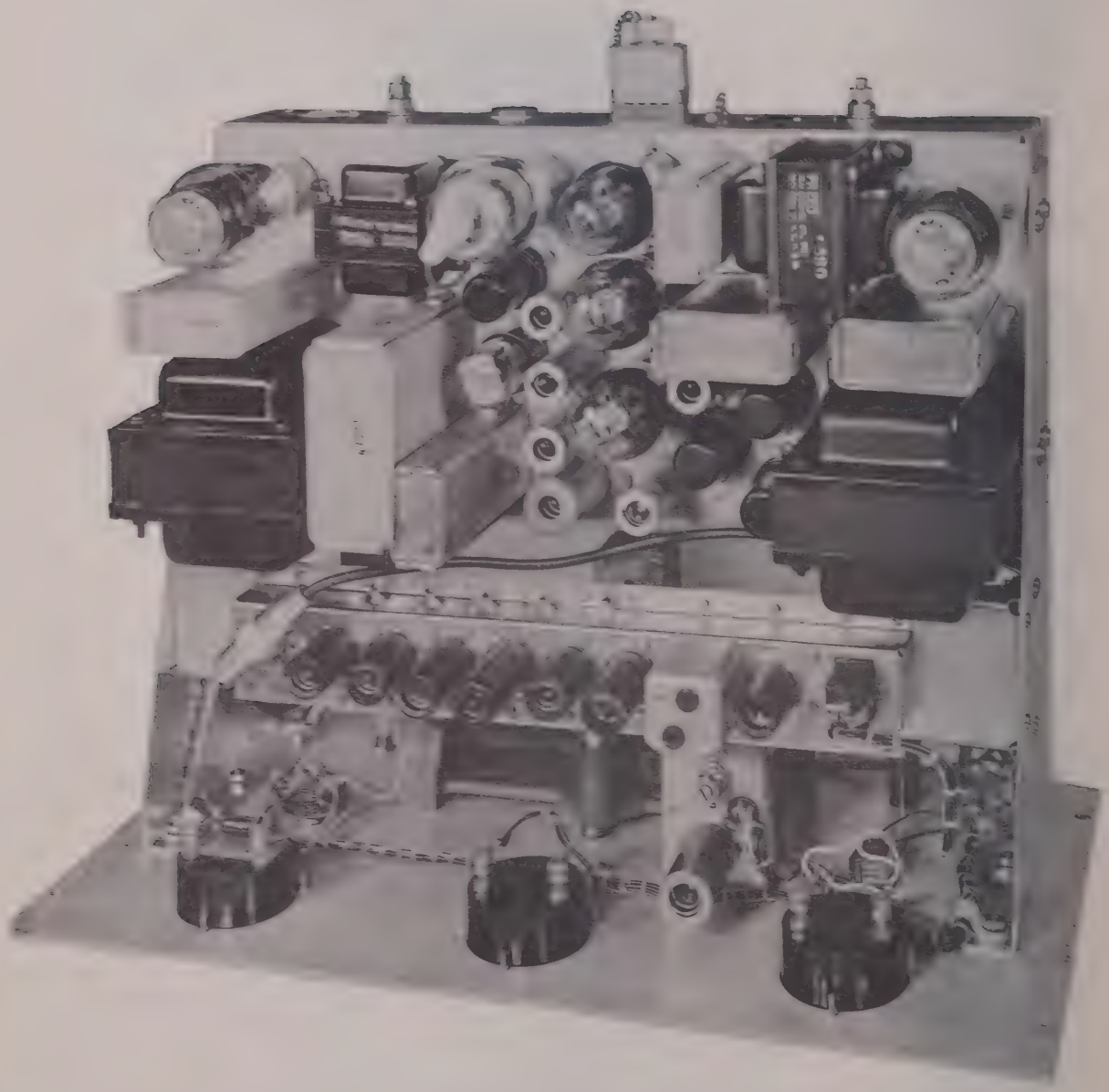


Figure 4-1. Model 296 Microwave Receiver - Top View

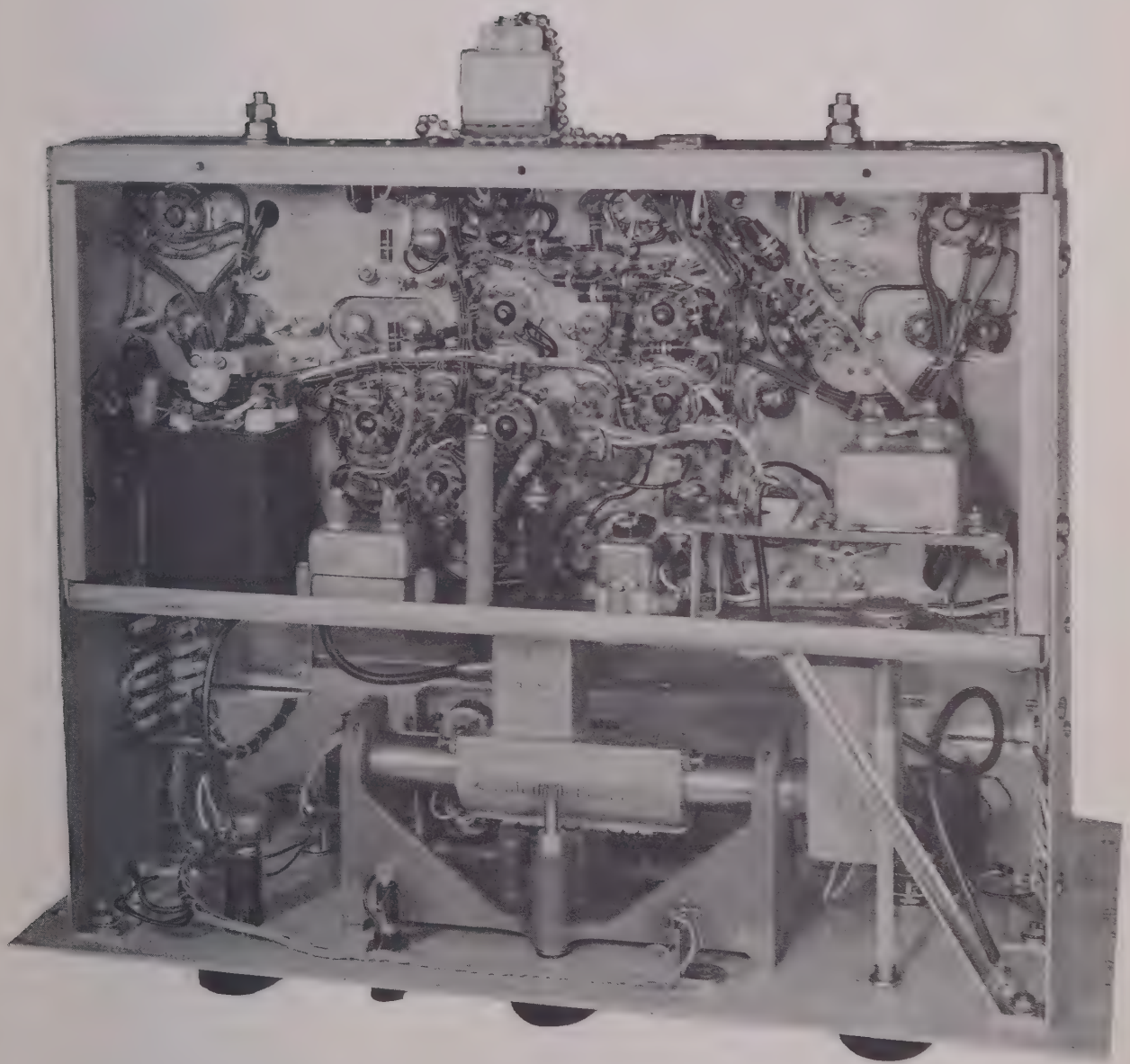


Figure 4-2. Model 296 Microwave Receiver - Bottom View

3. VOLTAGE MEASUREMENTS

a. The following table of tube pin voltages will aid the maintenance technician to localize troubles in this instrument. The table also covers the preamplifier, the schematic of which is shown in figure 5-3. All measurements should be made using a vacuum-tube voltmeter. The a-c input voltage should be set at 115 volts with proper loads (see paragraph 2, this section) used on the beam supply and plate supply. For reference purposes, wiring diagrams of the klystron cable and shorting plug are shown in figure 5-2.

b. Test-voltage measurements should be performed with the LOCAL OSCILLATOR meter selector switch set to the 0-1KV. position. Adjust BEAM VOLTAGE control for maximum after placing the 115 V a-c primary power switch to the ON position.

WARNING

THE SAFEST PROCEDURE WHEN MAKING THESE TEST-VOLTAGE MEASUREMENTS IS TO CONNECT THE GROUND TEST LEAD PERMANENTLY TO THE CHASSIS SO THAT ONLY ONE HAND NEED BE USED TO PERFORM THE VOLTAGE MEASUREMENTS.

TABLE 4-1. TUBE PIN VOLTAGES

Tube No.	Pin No. 1	2	3	4	5	6	7	8	CAP
V-101		380		-860		-860		380	
V-102		360	- 33						250
V-103		-170	- 33		-180		-170	-170	
V-104	-320	-185	-320	-330		-320	-180	-180	
V-105*							-105		
V-106*	-105						-210		
V-107*	-210						-315		
V-108		-400						400	
V-109			380	380	240			250	
V-110			380	380	240			250	
V-111			110	105		260		260	
V-112			250		100			115	
V-113*					105				
V-114**			5.2	0		190		120	
V-115**			260	260	120			160	
V-116**	-14***				230	160	-14***		
V-117**	Check voltage between reflector (pin A) and cathode (pin E) at J-103; this voltage varies from -10 to -500 dependent upon setting of REFLECTOR control on front panel. Remove V-102 during this measurement.								

* The light from the tube should not fluctuate.

** Remove V-203 during these measurements and A.F.C. TUNING meter should read near center.

*** Use r-f probe during this measurement.

4. ALIGNMENT PROCEDURES

a. General - In order to obtain best performance from this instrument, the attenuator, i-f amplifier, discriminator and afc circuits must be properly aligned. Refer to figures 5-4 and 5-5. The sequence of steps described herein should be followed.

b. Tune-Up Sequence.

(1) Connect a signal generator with an output impedance of 50 ohms (non-reactive) to receptacle J-201 which is mounted on the i-f amplifier chassis. Set the frequency to 30 mc (±0.5 mc) and adjust the output level control to give approximately half-scale deflection on the I.F. LEVEL meter. Remove V-207. Adjust potentiometer R-405 to bring the A.F.C. TUNING meter pointer to zero. The potentiometer is located on the small chassis at the back of the panel between the I.F. LEVEL meter and the A.F.C. TUNING meter. Replace V-207. Then adjust the signal-generator frequency slightly until the tuning meter reads zero. This frequency should correspond to the maximum reading on the I.F. LEVEL meter. If these do not coincide, tune L-201 until the peak reading on the I.F. LEVEL meter corresponds to the zero on the A.F.C. TUNING meter.

(2) Check the discriminator output by connecting a scope to the F.M. AUDIO receptacle and a sweep generator to receptacle J-201 on the i-f amplifier. The peaks on the discriminator curve should be approximately equal in amplitude and spaced symmetrically about the zero point.

(3) Adjust the signal generator for the same frequency as in paragraph 4b(1) and connect it to the 30 MC. INPUT receptacle at the receiver. Then tune the circuits at both ends of the attenuator (C-401 and C-403) for maximum reading on the I.F. LEVEL meter.

NOTE

Retuning of the discriminator transformer is not recommended unless a performance check of the i-f strip assembly shows the normal characteristics to be badly distorted.

(4) Discriminator-transformer retuning or major repair of the i-f strip assembly is indicated if measurements show a deviation from the following rated operating characteristics:

(a) I-f center frequency: 30 ± 0.5 mc.

(b) Gain: Approximately 10 microvolts measured at J-201 should produce a 10-microampere indication on the I.F. LEVEL meter.

(c) Bandwidth: 1 mc minimum between points at which the response is 3-db down.

(d) Discriminator center frequency: capable of being tuned to coincide with the center of the i-f amplifier passband.

(e) Discriminator bandwidth½ minimum 1.3 megacycles between peaks.

(f) Discriminator output at peaks: ±3.5 volts.

c. Discriminator Alignment - If tuning of the discriminator should be necessary, proceed as follows:

(1) Connect a sweep generator to J-201 and an oscilloscope to the I.F. LEVEL panel jack. The resulting pattern will be the response curve of the amplifier. Set a marker at the peak of this response curve.

(2) Connect the oscilloscope to the F.M. AUDIO jack. This pattern will be the response curve of the discriminator. Adjust the tuning screws at the top of the discriminator transformer for best symmetry and zero crossover at the marker frequency. The bandwidth between peaks should be a minimum of 1.3 megacycles.

(3) Realign the afc, i-f amplifier, and the attenuator, following the alignment procedure previously described in paragraph 4b.

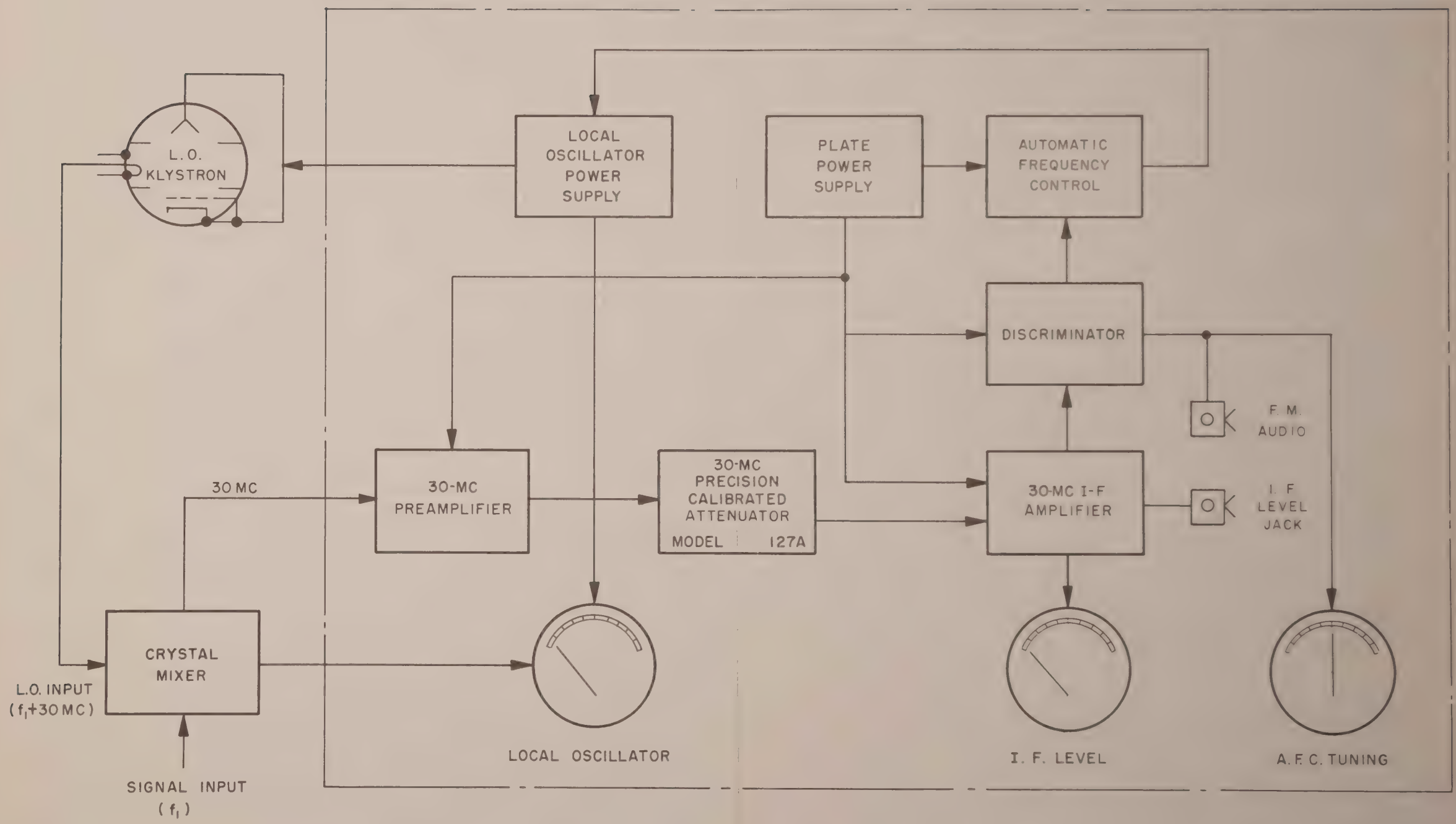


Figure 5-1. Model 296 Microwave Receiver - Block Diagram

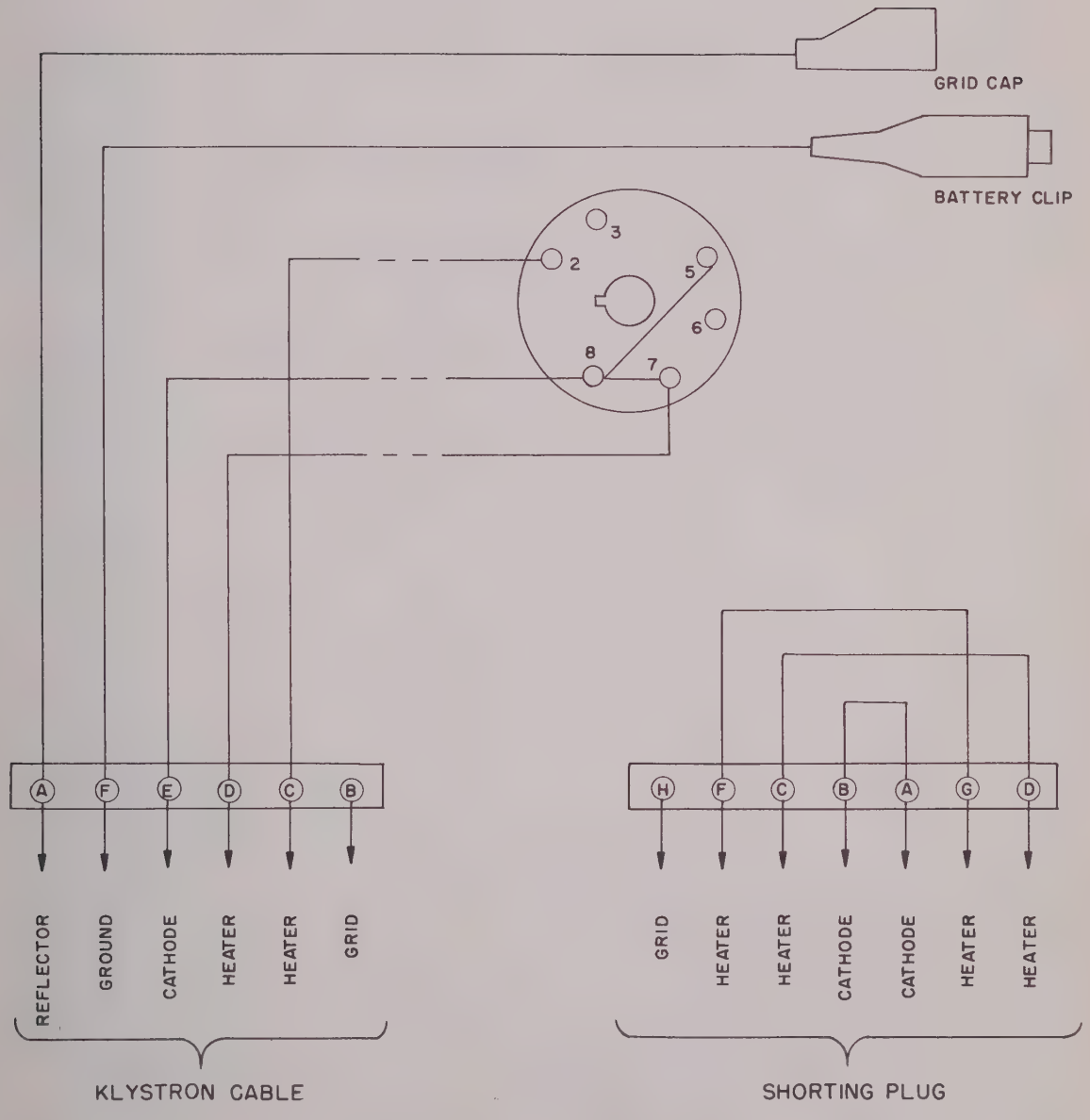
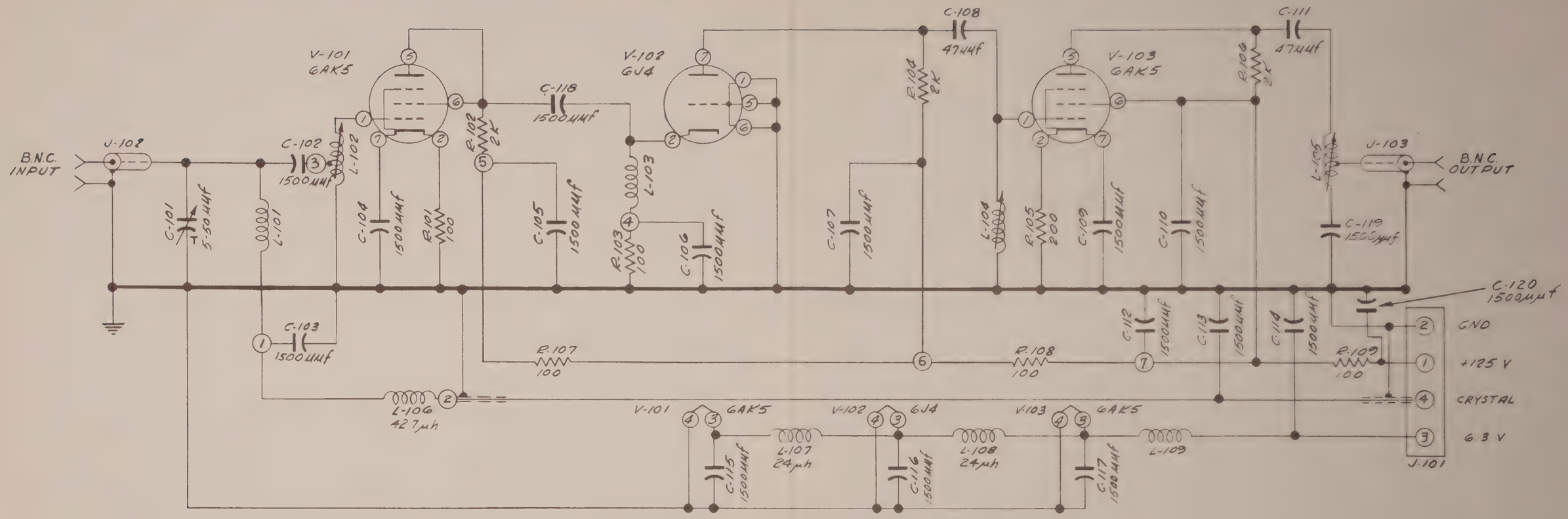


Figure 5-2. External Klystron Cable and Shorting Plug - Wiring Diagrams



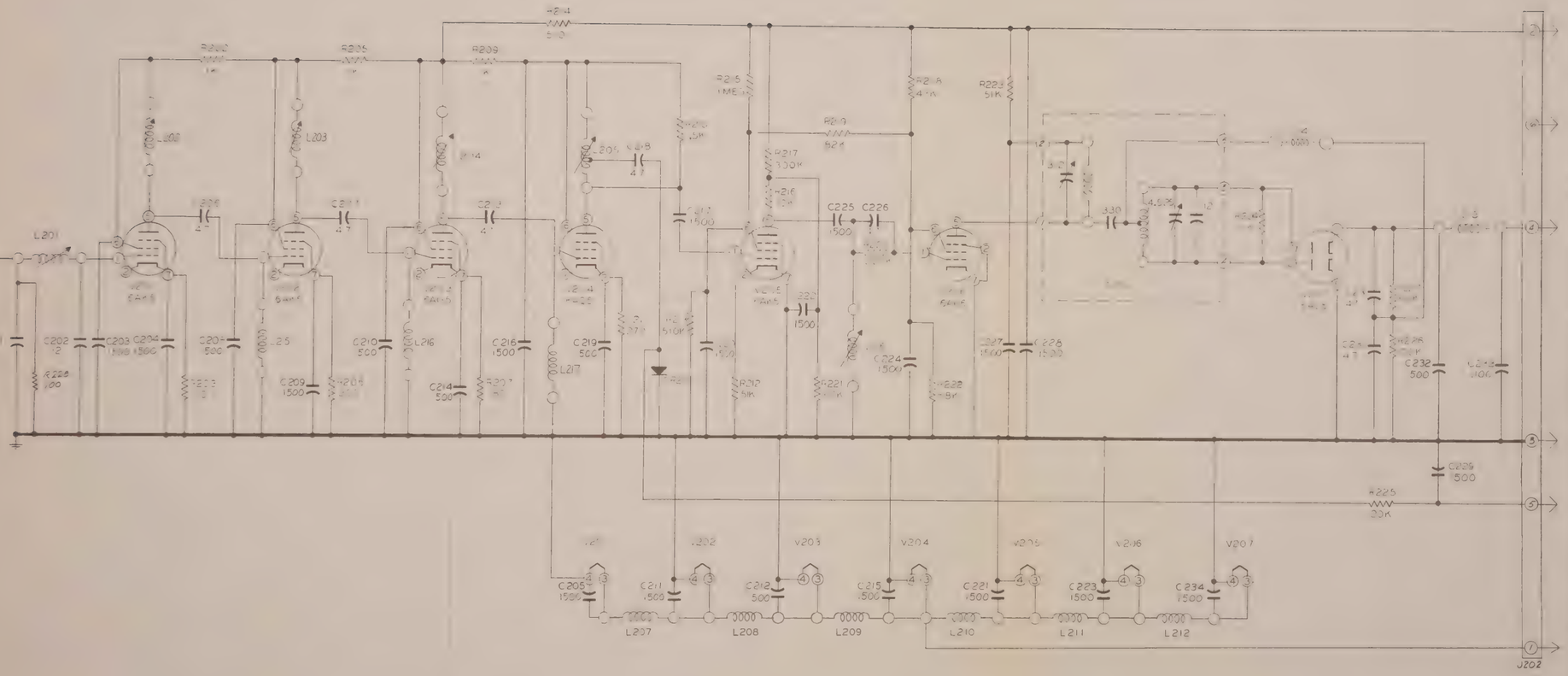
SYMBOL	PART NO. SEE NOTE	DESCRIPTION	VALUE	TOL.	RATING
C-101	0282-5	CAPACITOR-VAR	5-50 µµf	± 10%	500V DCW
C-102	813062-14	CAPACITOR	1500 µµf		300V DCW
C-103					
C-104					
C-105					
C-106					
C-107					
C-108	0323-47		47 µµf		500 V
C-109	813062-14		1500 µµf		300 V
C-110					300 V
C-111	0323-47		47 µµf		500 V
C-112	813062-14		1500 µµf		300 V
C-113					
C-114					
C-115					
C-116					
C-117					
C-118					
C-119					
C-120					
J-101	274413	PLUG			
J-102	813848	CONNECTOR			
J-103	813848	CONNECTOR			

SYMBOL	PART NO. SEE NOTE	DESCRIPTION	VALUE	TOL.	RATING
L-101	825234	COIL			
L-102	825233				
L-103	825235				
L-104	825236				
L-105	825232				
L-106	219382		42.7 µh	± 2%	
L-107	273776	CHOKE			
L-108					
L-109					
R-101	813186-25	RESISTOR	100	± 5%	1/2 W
R-102	-56		2K		
R-103	-25		100		
R-104	-56		2K		
R-105	-32		200		
R-106	-56		2K		
R-107	-25		100		
R-108	-25		100		
R-109	-25		100		
V-101	807787-2	TUBE-ELECTRON (6AK5)			
V-102	814569-2	(6J4)			
V-103	807787-2	(6AK5)			

SOCKET PIN NO.	V101 6AK5	V102 6J4	V103 6AK5
1	0	0	0
2	1.1 V D.C.	.85 V	1.9 V D.C.
3	6.3 V A.C.	6.3 V A.C.	6.3 V A.C.
4	0	0	0
5	96 V D.C	0	.10 V D.C
6	96 V D.C	0	125 V D.C.
7	1.1 V D.C	105 V D.C.	1.9 V D.C.
PLATE CURRENT	11 Ma. (TOTAL)	8.5 Ma.	7 Ma.
SCREEN CURRENT	INCLUDED IN PLATE		3 Ma.
VOLTAGES MEASURED WITH VTVM WITH NO SIGNAL			

NOTE: ALL PART NOS. ARE FOR REFERENCE ONLY
ALL VALUES EXPRESSED IN OHMS,
MICROMICROFARADS OR MICROHENRIES,
UNLESS OTHERWISE SPECIFIED.
K DENOTES 1000 OHMS
MEG DENOTES 1,000,000 OHMS.

Figure 5-3. Model 296 Microwave Receiver - Preamplifier Schematic



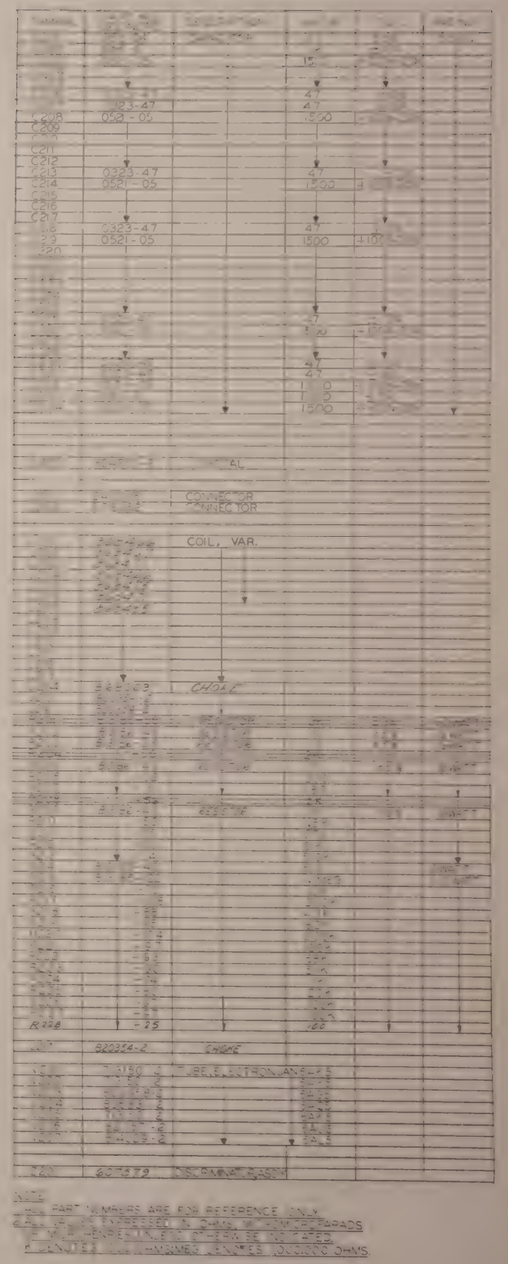
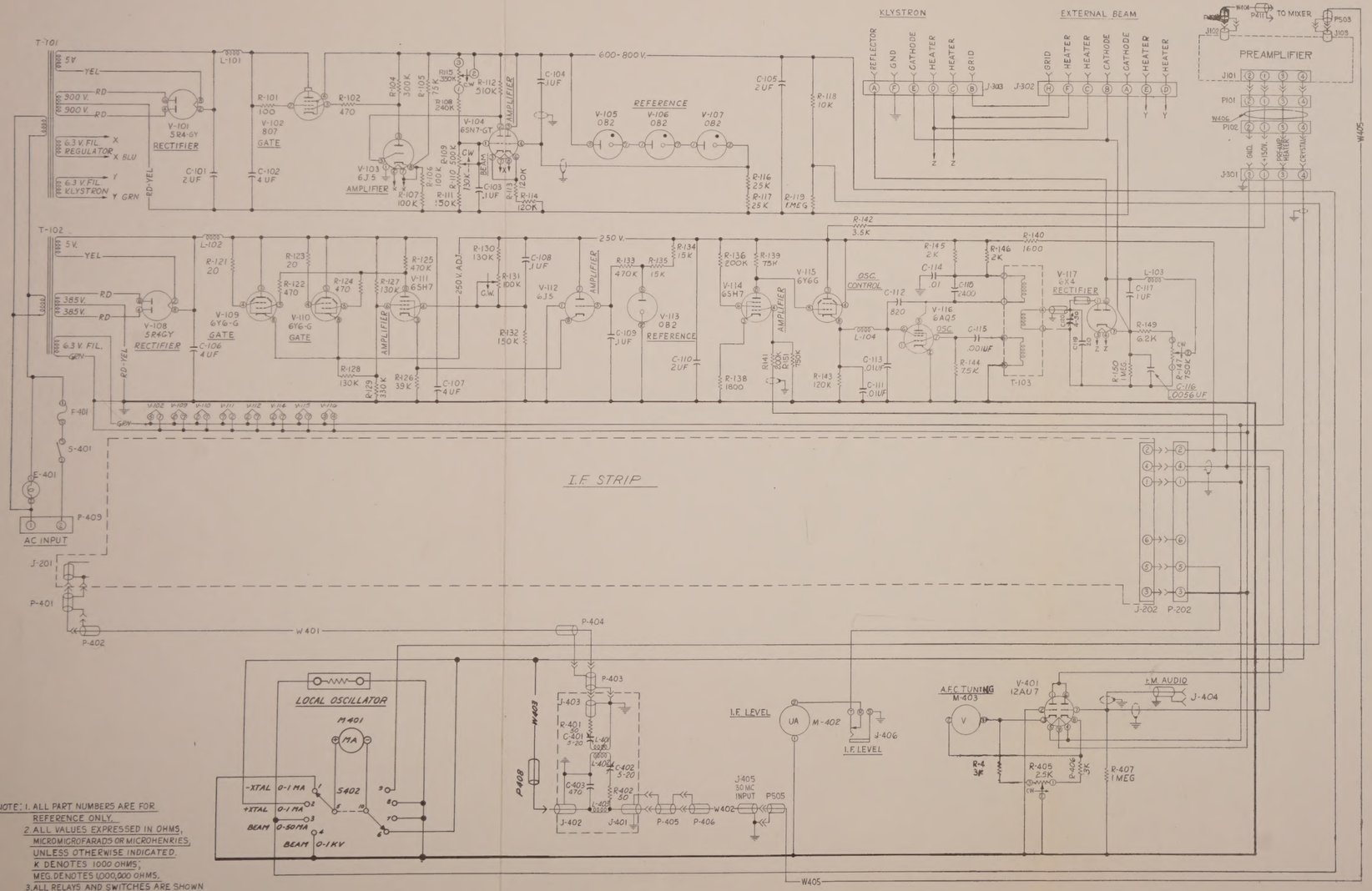


Figure 5-4. Model 296 Microwave Receiver - IF Amplifier Schematic



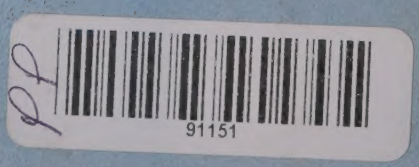
NOTE: 1. ALL PART NUMBERS ARE FOR REFERENCE ONLY.
2. ALL VALUES EXPRESSED IN OHMS, MICROMICROFARADS OR MICROHENRIES, UNLESS OTHERWISE INDICATED. K DENOTES 1000 OHMS; MEG DENOTES 1,000,000 OHMS.
3. ALL RELAYS AND SWITCHES ARE SHOWN IN THE UNENERGIZED OR OFF POSITION, UNLESS OTHERWISE INDICATED.

SYMBOL	PART NO (SEE NOTE)	DESCRIPTION	VALUE	TOL	RATING
C-101	041-5	CAPACITOR	2UF	±??%	150V
C-102	041-6		4 UF	±??%	150V
C-103	032-2		1UF	±10%	600V
C-104	034-2		1UF	±10%	600V
C-105	040-25		2 UF	±??%	1000V
C-106	040-6		4 UF	±??%	600V
C-107	040-6		4UF	±??%	600V
C-108	035-2		1UF	±10%	600V
C-109	034-2		1UF	±10%	600V
C-110	040-5		2UF	±??%	600V
C-111	0161-28		.01UF	±5%	1000V
C-112	0155-54		820UUF		
C-113	0161-28		.01UF		
C-114	0161-28		.01UF		
C-115	0161-4		.001UF		500V
C-116	018-14		.0056UF	±10%	600V
C-117	038-37		1UF	±10%	1000V
C-118	0161-13		2400	±5%	500V
C-119	011-14		20	±5%	500V
C-120	0282-3		4-80	—	500V
J-301	274412	SOCKET			
J-302	288518	CONNECTOR			
J-303	852498				
L-101	706308	REACTOR			
L-102	706309	REACTOR			
L-103	267691	R.F. CHOKE			
L-104	227508	R.F. CHOKE			
R-101	072-25	RESISTOR	100	±5%	1 W
R-102	070-21		470	±10%	½ W
R-103	070-58		68MEG	±10%	½ W
R-104	069-108		500K	±5%	½ W
R-105	075-94		7.5K	±5%	2W
R-106	075-97		100K	±5%	2W
R-107	075-97		100K	±5%	2W
R-108	075-106		240K	±5%	2 W
R-109	0192-107		500K	±20%	2W
R-110	070-100		130K	±10%	1 W
R-111	072-101		150K	±10%	1 W
R-112	069-114		510K	±10%	½ W
R-113	072-99		120K	±5%	1W
R-114	072-99		120K	±5%	1W
R-115	0192-106		350K	±20%	2W
R-116	280199		25K	±5%	10W
R-117	280199		25K	±5%	10W
R-118	070-37		10K	±10%	½W
R-119	223459-098		1MEG	±1%	2W
R-121	069-8		20	±5%	½W
R-122	070-21		470	±10%	½W
R-123	069-8		20	±5%	½W
R-124	070-21		470	±10%	½W
R-125	070-57		470K	±10%	½W
R-126	070-44		39K	±10%	½W
R-127	069-100		130K	±5%	½W
R-128	069-100		130K	±5%	½W
R-129	070-55		330K	±10%	½W
R-130	069-100		130K	±5%	½W
R-131	0192-103		100K	±20%	2W
R-132	070-51		150K	±10%	½W
R-133	070-57		470K	±10%	½W
R-134	073-39		15K	±10%	1W
R-135	073-39		15K	±10%	1W
R-136	072-104		200K	±5%	1W
R-137	072-93		68K	±5%	1W
R-138	072-55	RESISTOR	1800	±5%	1W
R-139	072-96		75K	±5%	1W
R-140	0102-85		1600	±5%	18W
R-141	069-104		200K	±5%	½W
R-142	0101-92		3.5K	±5%	12W
R-143	073-50		120K	±10%	1W
R-144	069-90		75K	±5%	½W
R-145	075-56		2K	±5%	2W
R-146	075-56		2K	±5%	2W
R-147	0192-109	Y - WAR	750K	±20%	2W
R-148	072-116		510K	±5%	1W
R-149	069-69	RESISTOR	6.2K	±5%	½ W
R-150	072-121		1MEG	±5%	1W
R-151	069-118		750K	±5%	½W
R-152	069-9		22	±5%	½W
T-101	706305	TRANSFORMER			
T-102	706302				
T-103	718576				

SYMBOL	PART NO (SEE NOTE)	DESCRIPTION	VALUE	TOL.	RATING
V-101	805147-2	VACUUM TUBE 5R4GY			
V-102	805228-2		807		
V-103	805400-2		6J5		
V-104	808081-2		6SN7-GT		
V-105	818236-2		OB2		
V-106	818206-2		OB2		
V-107	818236-2		OB2		
V-108	805147-2		5R4-GY		
V-109	807594-2		6Y6-G		
V-110	807594-2		6Y6-G		
V-111	805981-2		6SH7		
V-112	805400-2		6J5		
V-113	818236-2		OB2		
V-114	805812-2		6SH7		
V-115	807594-2		6Y6G		
V-116	806831-2		6AQ5		
V-117	820102-2		6X4		
C-202	0291-40	CAPACITOR	1500UUF	±20%	500V
C-203	0291-40		1500UUF	±20%	500V
C-204	0323-47		47UUF	±10%	500V
C-205	0291-40		1500UUF	±20%	500V
C-206	0291-40		1500UUF	±20%	500V
C-207	0323-47		47UUF	±10%	500V
C-208	0291-40		1500UUF	±20%	500V
C-209	0291-40		1500UUF	±20%	500V
C-210	0323-47		47UUF	±10%	500V
C-211	0291-40		1500UUF	±20%	500V
C-212	0291-40		1500UUF	±20%	500V
C-213	0323-47		47UUF	±10%	500V
C-214	0291-40		1500UUF	±20%	500V
C-215	0291-40		1500UUF	±20%	500V
C-216	0323-47		47UUF	±10%	500V
C-217	0291-40		1500UUF	±20%	500V
C-218	0291-40		1500UUF	±20%	500V
C-219	0323-47		47UUF	±10%	500V
C-220	0323-47		47UUF	±10%	500V
C-221	0291-40		1500UUF	±20%	500V
C-222	0291-40		1500UUF	±20%	500V
C-223	0291-50		2500UUF	±20%	500V
C-224	0291-40		1500UUF	±20%	500V
C-225	0291-40		1500UUF	±20%	500V
C-226	0291-40		1500UUF	±20%	500V
CR-201	824255-2	CRYSTAL RECT.	IN43		
L-201	845503	COIL			
L-202	822770				
L-203	822772				
L-204	845398				
L-205	845394				
L-206	845495				
L-207	822770				
J-201	240566	CONNECTOR NAVY-TYPE	49194		
J-202	278352	CONNECTOR			
P-202	822722	PLUG			
R-202	813186-56	RESISTOR	2K	5%	½W
R-203	-26		110		
R-204	-45		1K		
R-205	-58		2K		
R-206	-32		200		
R-207	-49		1K		
R-208	-31		180		
R-209	-49		1K		
R-210	-56		2K		
R-211	813190-42		510		2W
R-212	813186-33		270		½W
R-213	-56		2K		
R-214	-75		12K		
R-215	-90		51K		
R-216	-90		20K		
R-217	-42		510		
R-218	-63		3.9K		
R-219	-90		51K		
R-220	-90		51K		
R-221	072-32		200		1W
R-222	813186-49		1K		½W
T-201	672809	TRANSFORMER			
V-201	807787-2	VACUUM TUBE 6AK5			
V-202	807787-2	VACUUM TUBE 6AK5			

SYMBOL	PART NO (SEE NOTE)	DESCRIPTION	VALUE	TOL.	RATING
V-203	805958-2	VACUUM TUBE 6AG5			
V-204	806831-2	6AQ5			
V-205	807787-2	6AK5			
V-206	814029-2	6AL5			
C-401	028-22	CAPACITOR	5-300UUF		500V
C-402	028-22		5-300UUF		500V
C-403	813062-11		470UUF		300V
F-401	042-12	FUSE			3AMP
E401	265283	LAMP NE-51			
J-401	240566	CONNECTOR NAVY TYPE 49194			
J-402					
J-403					
J-404	813848	RECEPTACLE UG-290/U			
J-405	813850	RECEPTACLE UG-291/U			
J-406	227571	JACK			
L-401	238409	COIL			
L-402	278405				
L-403	5266049				
M-401	822755	METER			0-1MA
M-402	0273-2				0-500A
M-403	718015-01				3-0-3V
P-401	222676	PLUG NAVY TYPE 49192A			
P-402	238797	49190			
P-403	222676	49192A			
P-404	238797	49190			
P-405	222676	49192A			
P-406	238797	49190			
P-407	222676	49192A			
P-408	238797	PLUG NAVY TYPE 49190			
P-409	252432	PLUG			
R-401	069-17	RESISTOR	50	±5%	½W
R-402	069-17	RESISTOR	50	±5%	½ W
R-403	813186-97		100K	±5%	2W
R-404	813186-60	RESISTOR	5K	±5%	½ W
R-405	0192-93	-VAR	2.5K	±20%	2W
R-406	813186-60		3K	±5%	½W
R-407	813186-121		1MEG	±5%	½W
R-408	813186-52		1200	±5%	½W
R-409	813186-56		2000	±5%	½W
S-401	0232-1	SWITCH			
S-402	822782				
S-403	0233-4				
V-401	820151-2	TUBE ELECTRON 12AU7			
W-401	822781	CABLE ASSY			
W-402	735580				
W-403	284065				
W-404	842307				
W-405	672862				
W-406	113581				

Figure 5-5. Model 296 Microwave Receiver - System Schematic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